Agriculture and Agri-Food Canada
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Condiment Mustard Breeding: Update

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Outline of the Presentation

- Introduction
- Brown mustard hybrid variety
- Oriental mustard hybrid variety
- Yellow mustard varieties
- AAC Brown 18
- AAC Yellow 80
- Development of Group 2 herbicide tolerant brown mustard
- Future direction of mustard breeding
- Acknowledgements

Introduction

Objectives:

- Development of high-yielding varieties of brown and oriental mustards (*Brassica juncea*) and yellow mustard (*Sinapis alba*)

Approach:

- Brown and oriental mustard: Increase yield by using heterosis in hybrids using the Ogura cytoplasm male sterile (cm) system
- Yellow mustard: Increase yield by exploiting partial heterosis in synthetics

Develop high yielding hybrid varieties of brown mustard (*B. juncea*)

Highlight:

- Have developed diverse elite brown mustard Ogura cms male sterile (A) and restorer (R) lines
  - Germplasm: China, France, Germany, Turkey, Poland and Russia
- Have produced 34 hybrids.
- Evaluated the agronomic performance of the hybrids in 2021
- Evaluated the agronomic performance of 9 hybrids in the Mustard Adaptation Test (MAT) in 2022.
- Candidate variety: B3963

Summary of the agronomic performance of the brown mustard hybrid B3963 in the yield trial (SA1, SA2 and SW) in 2021

Entry	Yield		Oil	Protein	Seed color	Height	Maturit y	Seed WT	Chloro phyll	Allyl Wet
	Kg/Ha	% check	%	%	WI	Cm	Days to	g/1000s		µmole/g
Centennial Brown (check)	**1204**	100	**32.1**	**33.2**	**-5.7**	**108**	**74**	**2.92**	**2.1**	**135**
AAC Brown 18	**1370†**	**114**	**34.4‡**	**31.1‡**	**-6.0**	**110**	**73†**	**2.87**	**0.9‡**	**119‡**
B3963	**1455‡**	**121**	**34.7‡**	**31.9‡**	**-5.6**	**124‡**	**75**	**2.62‡**	**1.8**	**133**
F-Value	3.22**		22**	28**	47**	20.9**	8.8**	55**	17**	49**
LSD	146		0.68	0.73	0.63	4.96	1.18	0.09	0.32	5.4
Locations	3		3	3	3	3	2	2	2	2

Summary of the agronomic performance of the brown mustard candidate hybrid B3963 in the Mustard Adaptation Test (11 station year) in 2022

Entry	Yield		Seed WT	Oil	Protein	Color	Height	Lodging	Maturity
	Kg/Ha	% check	g/1000s	%	%	WI	Cm	1-5	Days to
Centennial Brown (check)	**1582**	**100**	**2.35**	**35.7**	**30.7**	**-5.22**	**116**	**1.1**	**82**
AAC Brown18	**1773‡**	**112**	**2.50**	**37.0‡**	**29.7‡**	**-6.27‡**	**116**	**1.1**	**82**
B3963	**1796‡**	**114**	**2.40**	**36.9‡**	**30.5**	**-5.44**	**139‡**	**1.1**	**85‡**
F-Value	12.0**		32.6**	92.6**	123**	20.3**	55.0**	1.49^{ns}	33.2**
LSD	86.6		0.15	0.32	0.31	0.58	4.24		0.69
Locations	11		3	11	11	11	9	9	7

Develop high yielding hybrid varieties of oriental mustard (*B. juncea*)

Highlight:

- Have developed diverse elite oriental mustard Ogura cms A and restorer (R) lines
  - Germplasm: Australia, China, France, Germany, Turkey, Poland and Russia
- Have produced 47 hybrids.
- Evaluated the agronomic performance of the hybrids in 2021
- Evaluated the agronomic performance of 6 hybrids in the Mustard Adaptation Test in 2022.
- Candidate varieties: O3841 and O3848

Agronomic performance of the oriental mustard hybrids O3841 and O3848 in the yield trial in 2021

Entry	Yield		Seed WT	Oil	Protein	Allyl glu	Chlorophyll	Seed color	Maturity	Height
	Kg/Ha	%Cutlass	g/1000seeds	%	%	µmole/g		WI	Days to	Cm
Cutlass (check)	**1351**	**100**	**2.62**	**38.1**	**30.4**	**138**	**0.34**	**-46.7**	**73**	**101**
O3841	**1615‡**	**120**	**2.60**	**37.4†**	**31.9‡**	**146‡**	**0.41**	**-40.3‡**	**74‡**	**107†**
O3848	**1683‡**	**125**	**2.66**	**36.8‡**	**30.8**	**128‡**	**0.51**	**-37.2‡**	**74‡**	**108†**
F-Value	9.3**		9.3**	22**	12**	23**	3.3**	14**	8.4**	4.9**
LSD	103		0.14	0.60	0.56	5.02	0.21	0.18	0.74	5.6
Locations	3		2	3	3	2	2	3	2	3

Agronomic performance of the oriental mustard candidate hybrids O3841 and O3848 in the Mustard Adaptation Test in 2022

Entry	Yield		Seed WT	Oil	Protein	Color	Height	Lodging	Maturity
	Kg/Ha	%Cutlass	g/1000s	%	%	WI	Cm	1-5	Days to
Cutlass	**1728**	**100**	**1.99**	**40.9**	**28.8**	**-39.2**	**117**	**1.1**	**82**
O3841	**1943 ‡**	**112**	**2.20**	**40.1 ‡**	**29.8 ‡**	**-33.8 ‡**	**125‡**	**1.1**	**83**
O3848	**2019‡**	**117**	**2.23‡**	**39.9 ‡**	**28.9**	**-32.1 ‡**	**120**	**1.1**	**82**
F-Value	8.15**		85**	47**	30**	104**	35.5**	1.36 ns	9.96**
LSD	80.6		0.07	0.32	0.30	0.71	3.55		0.51
Locations	11		3	11	11	11	9	9	7

Develop high yielding synthetic varieties of yellow mustard (*S. alba*)

Highlights:

- Have developed diverse elite inbred lines via pedigree breeding
  - Germplasm: England, Germany, Italy, Korea, Spain, Sweden
- Have produced 33 synthetic lines
- Have evaluated the agronomic performance of the synthetic lines in 2021
- Have evaluated 10 synthetic lines in the Mustard Adaptation Test in 2022
- Candidate synthetic lines: Y4015 and Y4016

Summary of the agronomic performance of the synthetic lines Y4015 and Y4016 in the yield trial in 2021

Entry	Yield		Seed	Oil	Protei n	Seed color	Mucilage	Height	Maturity
	Kg/Ha	%Andante	g/1000s	%	%	WI		cm	Days to
Andante (check)	**990**	**10.**	**4.44**	**25.7**	**38.1**	**-38.5**	**59**	**79**	**82**
Y4015	**1091‡**	**110**	**4.31†**	**25.9**	**37.5†**	**-41.6‡**	**67‡**	**81**	**82**
Y4016	**1084‡**	**110**	**4.33**	**26.2‡**	**37.1‡**	**-41.1‡**	**70‡**	**83**	**82**
F-Value	3.51**		2.77**	6.0**	4.8**	6.4**	8.13**	1.69 ^{ns}	1.43 ^{ns}
Lsd (0.05)	53.2		0.1	0.4	0.5	1.2	5.33		
Location	7		4	7	7	7	6	7	7

Summary of the agronomic performance of the candidate synthetic lines Y4015 and Y4016 in the Mustard Adaptation Test in 2022

Entry	Yield		Seed WT	Oil	Protein	Color	Maturity	Height	Lodge
	Kg/Ha	% checck	g/1000 seed	%	%	WI	Days to	Cm	1-5
Andante (check)	**1477**	**100**	**4.78**	**27.8**	**35.9**	**-35.3**	**77**	**120**	**1.24**
AAC Yellow 80	**1671‡**	**113**	**4.70**	**28.7 ‡**	**35.3 ‡**	**-39.1‡**	**78**	**119**	**1.16**
Y4015	**1640‡**	**111**	**4.46‡**	**28.5 ‡**	**34.7 ‡**	**-39.2‡**	**77**	**122**	**1.19**
Y4016	**1647‡**	**112**	**4.67**	**28.7 ‡**	**34.7 ‡**	**-38.9‡**	**78**	**125‡**	**1.27**
F-Value	8.41**		13.2**	6.96**	7.06**	18.3**	0.82 ^{ns}	4.40**	1.62 ^{ns}
LSD	49.3		0.14	0.34	0.40	0.76		2.89	
Locations	13		3	13	13	13		9	11

Summary of agronomic performance of AAC Brown18 in 2017, 2018, 2021 and 2022 (47 station years)

	Yield		**Seed Weight**	**Fixed Oil**	**Protein**	**GLS Allyl**	**Seed Colour**	**Distinct Green**	**Chloro-phyll**	**Height**	**Maturity**
	kg/ha	% Check	g/1000 seed	% whole seed		µmole/ g seed	WI E313	%	mg/kg seed	cm	days
Centennial Brown Check)	**1780**	**100**	**2.97**	**35.6**	**30.5**	**111**	**-4.78**	**0.11**	**3.79**	**123**	**85**
AAC Brown18	**2114‡**	**119**	**2.90‡**	**37.2‡**	**29.2‡**	**106‡**	**-5.77**	**0.13**	**3.38**	**126**	**85**
L.S.D. (5%)	47		0.03	0.18	0.16	2.04	0.31			1.65	
# station yrs	47		39	47	47	35	47	38	38	40	33

Agronomic performance of AAC Yellow 80 in 2019, 2020, 2021 and 2022 (45 station years)

	Yield		Seed Weight	Fixed Oil	Protein	GLS HoBe	Mucilage	Seed Colour	Distinct Green	Chloro-phyll	Height	Maturity
	kg/ha	% Check	g/1000 seed	% whole seed		µmole/ g seed		WI E313	%	mg/kg seed	cm	days
Andante (check)	**1637**	**100**	**5.67**	**28.1**	**35.5**	**143**	**82.4**	**-36.7**	**0.46**	**1.89**	**112**	**84**
AAC Yellow 80	**1785‡**	**109**	**5.62†**	**28.9‡**	**35.1‡**	**140**	**78.7**	**-39.9**	**0.44**	**1.97**	**114**	**84**
L.S.D. (5%)	31.8		0.05	0.15	0.17		2.47	0.39		0.29	1.41	
# station yrs	45		35	44	44	23	31	44	22	31	41	32

Creation of Group 2 herbicide tolerant brown mustard germplasm

- **Approach: Seed mutagenesis using ethyl methanesulfonate (EMS) and pedigree breeding**

  - Treated 1000 seeds of AAC Brown 120 with 0.6% EMS

Group 2 herbicide tolerant line: B4017-2-7-20

Test of B4017-2-7-20 for different Group 2 herbicide tolerance

<u>Herbicide susceptible lines:</u>

1. **Centennial Brown (check)**
2. **Wild-type AAC Brown 120 (check)**

<u>Herbicide tolerant line</u>

1. **B4017-2-7-20**

Test of the Group 2 herbicide tolerance of B4017-2-7-20

Group 2 herbicides:

- **Imidazolinones (IMI)**
  1) **Ares**
  2) **Odyssey**

- **Sulfonylureas (SU)**
  1) **Refine SG**

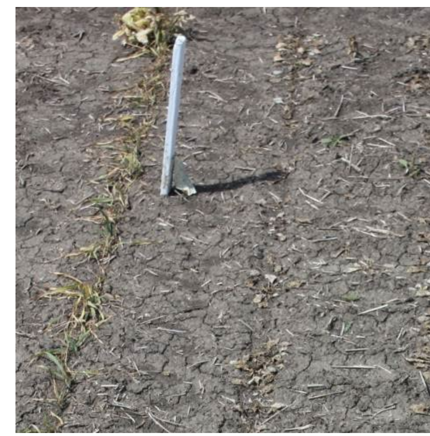
IMI herbicide: Ares at 1 X rate

Centennial Brown is susceptible to Ares.

Before spraying

2 weeks after spraying

3 weeks after spraying



IMI herbicide: Ares at 1 X rate

Wild-type AAC Brown 120 is susceptible to Ares.

Before spraying

2 weeks after spraying

3 weeks after spraying

IMI herbicide: Ares at 1 X rate

B4017-2-7-20 is tolerant to Ares.

Before spraying

2 weeks after spraying

3 weeks after spraying

IMI herbicide: Odyssey at 1 X rate

Centennial Brown is susceptible to Odyssey.

Before spraying

2 weeks after spraying

3 weeks after spraying

IMI herbicide: Odyssey at 1 X rate

Wild-type AAC Brown 120 is susceptible to Odyssey

Before spraying

2 weeks after spraying

3 weeks after spraying

IMI herbicide: Odyssey at 1 X rate

B4017-2-7-20 is tolerant to Odyssey.

Before spraying

2 weeks after spraying

3 weeks after spraying

SU herbicide: Refine SG at 1 X rate

Centennial Brown is susceptible to Refine SG.

Before spraying

2 weeks after spraying

3 weeks after spraying

SU herbicide: Refine SG at 1 X rate

Wild-type AAC Brown 120 is susceptible to Refine SG.

Before spraying

2 weeks after spraying

3 weeks after spraying

SU herbicide: Refine SG at 1 X rate

B4017-2-7-20 is susceptible to Refine SG.

Before spraying

2 weeks after spraying

3 weeks after spraying

Conclusion

B4017-2-7-20 is:

- **Tolerant to the Imidazolinone herbicides: Ares and Odyssey at 1x rate.**
- **Susceptible to the Sulfonylureas herbicide: Refine SG at 1x rate.**

Brown mustard yield trail in Saskatoon in 2014

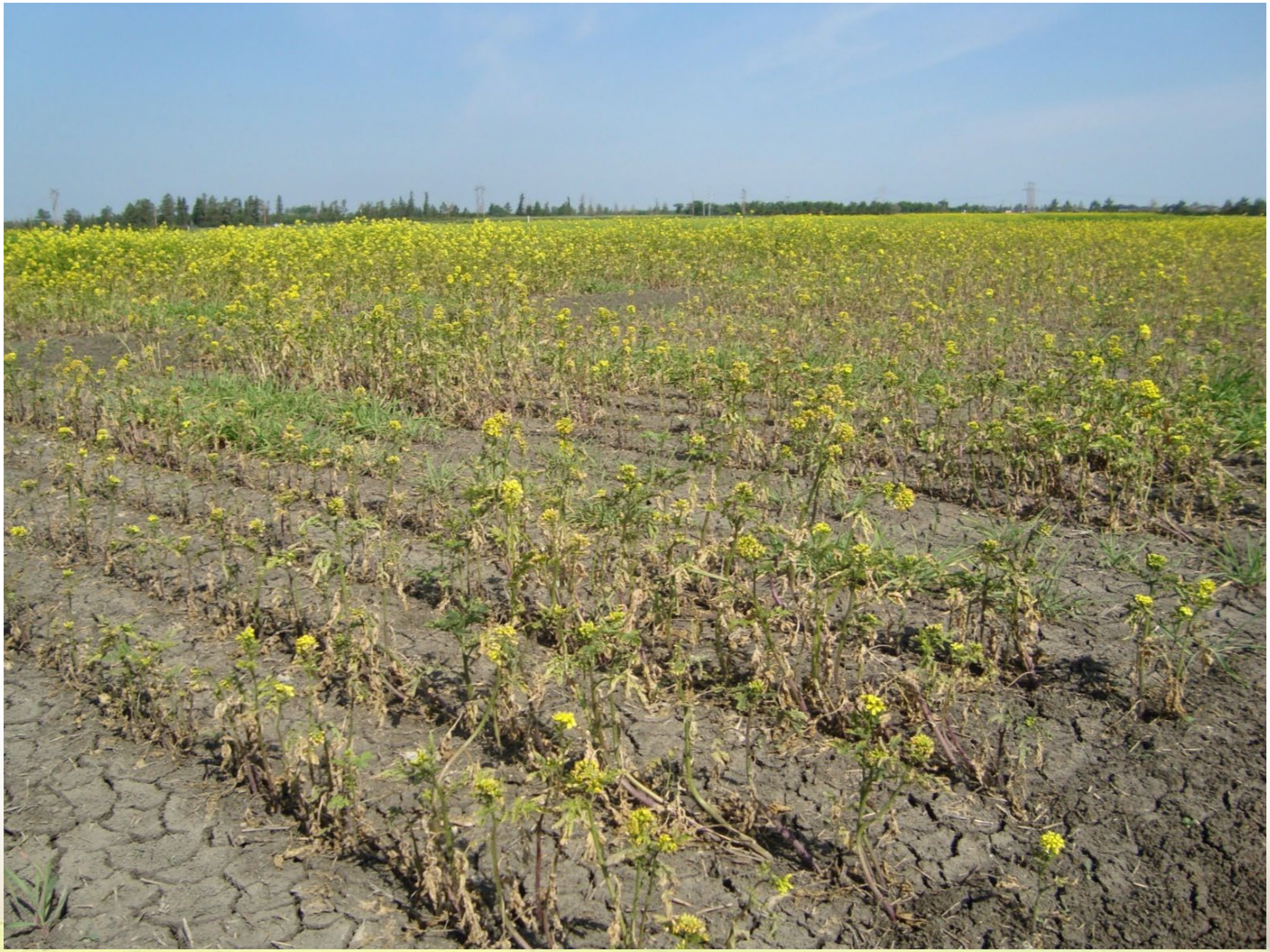
Before flooding

Brown mustard yield trail in Saskatoon in 2014

After flooding

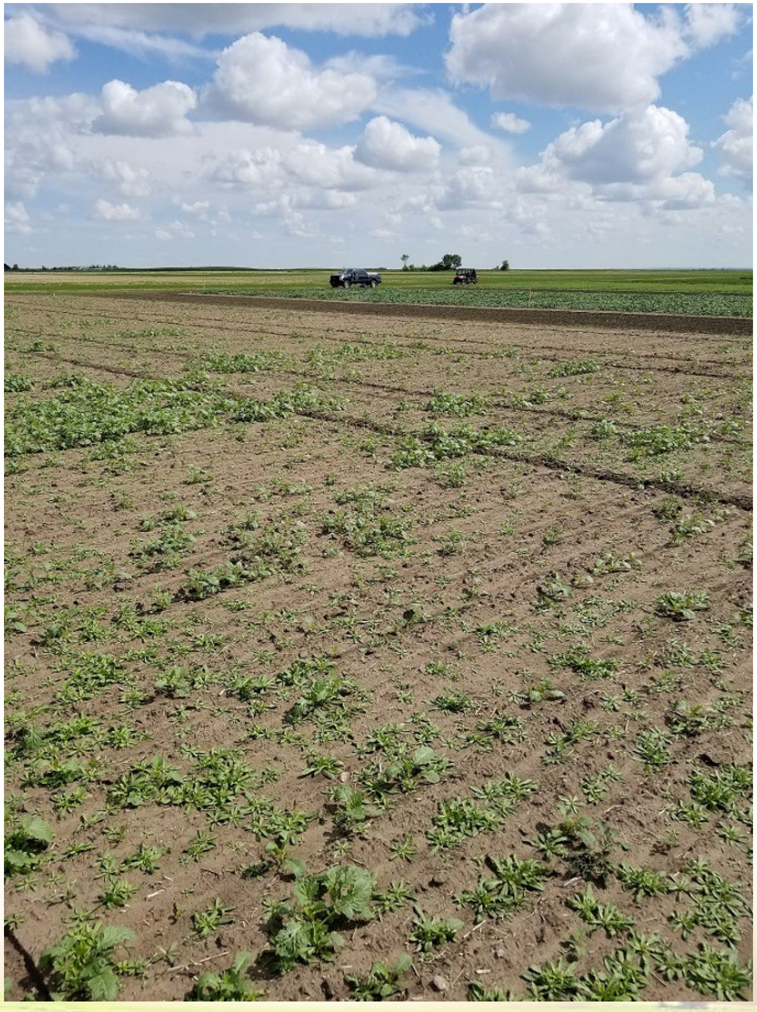
Yellow mustard yield trail in Saskatoon in 2014

After flooding



Hail damage of *B. juncea* yield trail in Coaldale in 2014

Frost damage of *B. juncea* trials in Redvers in 2021



Flea beetle damage of *B. juncea* trials in Saskatoon in 2022

Future direction of breeding

Biotic stress such as flea beetle damage, blackleg and clubroot diseases, and abiotic stresses (drought, flooding and frost) can lead to crop loss/ yield reduction.

To develop super varieties:

- High-yielding potential and desirable quality
- Yield protection traits
  - Disease resistance such as clubroot and blackleg
  - Flea beetle resistance
  - Abiotic stress tolerance: drought, flooding and frost

Future direction of breeding

Short term (next 5 years: 2023-2028) breeding objectives:

1. To develop Group II herbicide tolerant brown and oriental mustard hybrid varieties
2. To create Group II herbicide tolerant yellow mustard line
3. To develop clubroot resistant brown and oriental, and yellow mustard lines (In collaboration with Dr. Yangdou Wei, U of Saskatchewn)
4. To identify brown, oriental and yellow mustard germplasm with soil salinity tolerance (Dr. Raju Soolanayakanahally)

Long term (beyond next 5 years -)

1. To develop herbicide tolerant and clubroot resistant brown and oriental mustard hybrid varieties, and yellow mustard synthetic varieties
2. To create flea beetle resistant brown or oriental mustard germplasm
3. To create frost tolerant brown or oriental mustard germplasm

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